Form C 2644

Order No.

Drawing No.

Scale 1

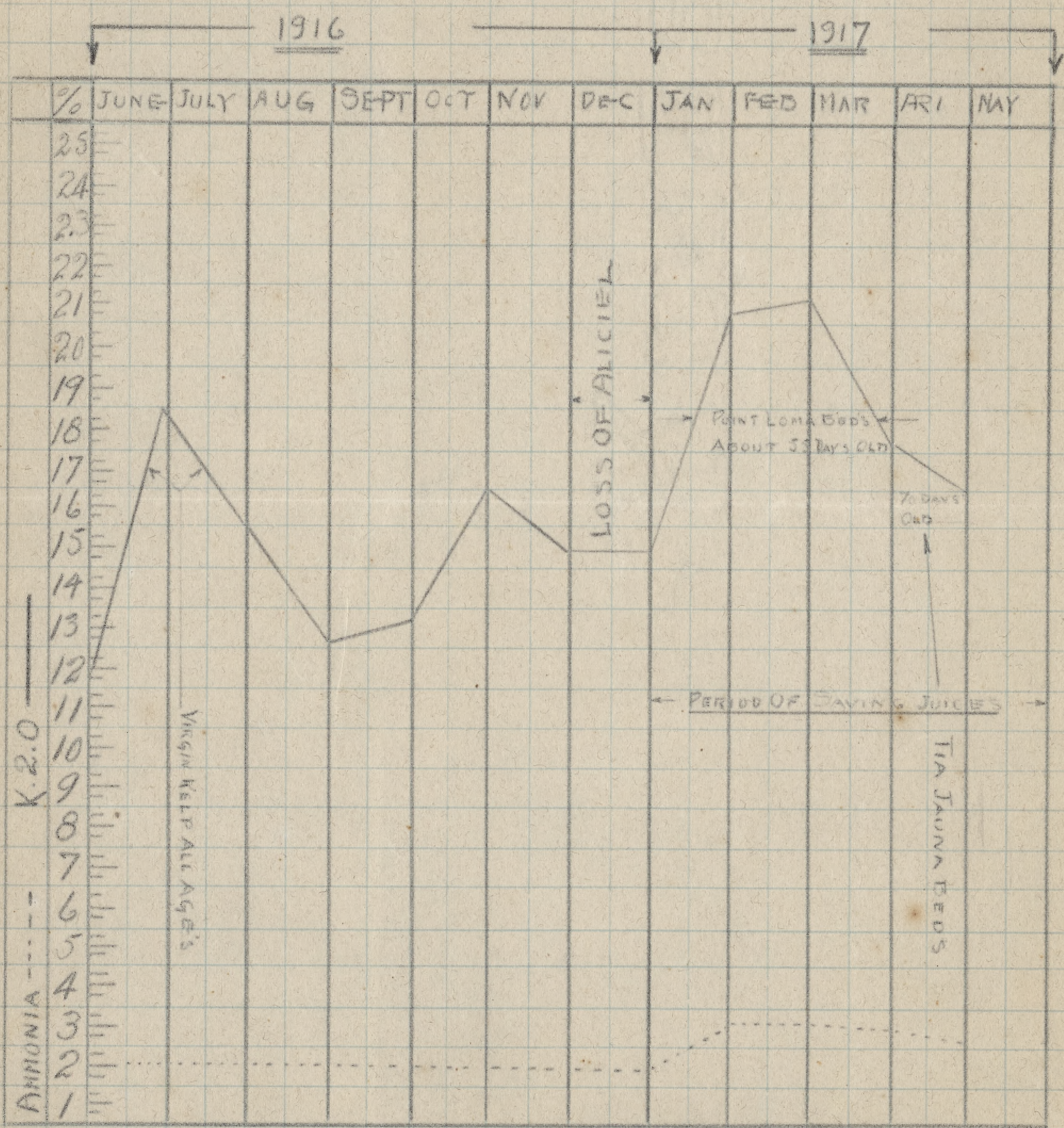
Swift & Company, U. S. Y.

Date JUNE 22nd 1917

Draftsman H.W.

Approved

RANGE OF CONTENT OF KELP THROUGHOUT ONE YEAR



Form C 2644

Order No. ....

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Swift & Company, U. S. Y.

Date .... 191....

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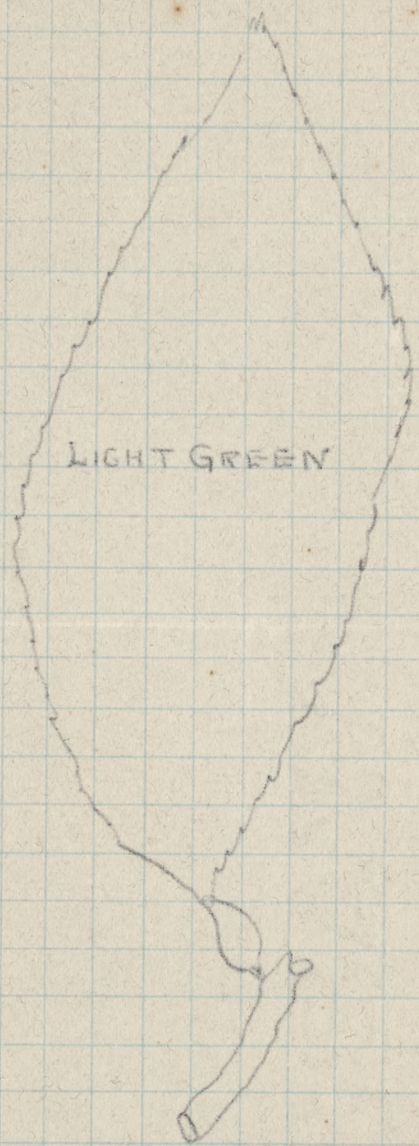

30 DAYS GROWTH AVERAGE K_2O CONTENT 12.25%

Form C 2644

Order No. .... | **Swift & Company, U. S. Y.** | Date .... 191....

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60 DAYS GROWTH AVERAGE K2.0 CONTENT 16%

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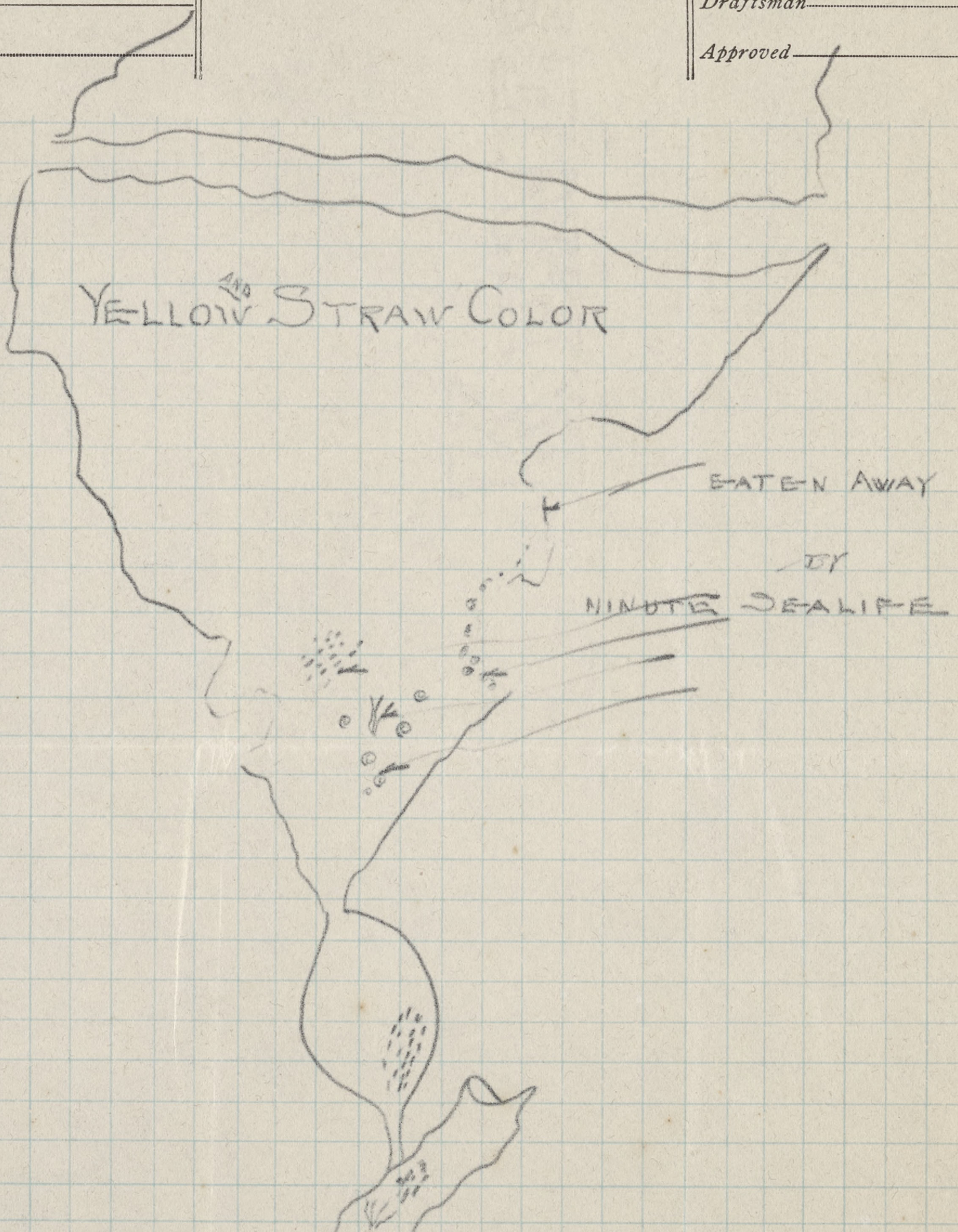

40 TO 60 DAYS OLD K2.0 CONTENT 16 TO 20%

60 TO 80 DAYS OLD 13% K2.0 CONTENT

Possibly for
Pac Fisherman
1-22-19

In a little laboratory facing Glorietta Bay, near Coronado, Mr. David M. Balch, who might be called the Father of the present kelp industry of the Pacific Coast, wrote an article for the Journal of Industrial and Engineering Chemistry, December 1909, in which he gave the chemical analysis of kelp. This analysis being brought to the attention of the Bureau of Soils of the Department of Agriculture at Washington, suggested to them a possible source of potash, and in 1911, investigations of the matter were placed under the supervision of Doctor Frank K. Cameron (of the Bureau of Soils). Doctor Cameron asked Doctor William E. Ritter, Director of the Scripps Institution at La Jolla, to furnish a man who could study the kelp and survey the beds from San Diego to Point Conception, and, as a result of circumstance, the writer of this article was assigned to the work, with the Marine Biological Research boad, the Alexander Agassiz, placed at his disposal.

During the fall of 1911, a survey was accordingly made of the kelp beds along the coast between San Diego and Point Conception, and about the islands adjacent to that coast. At the same time a similar survey of the beds from Monterey to San Francisco was made by Doctor Frank Mace McFarland; and of the beds about Puget Sound, by Doctor G. B. Rigg.

The facts learned from these investigations seemed so promising, that in 1912, the writer was authorized by the Department of Agriculture to make another survey from San Diego to Neah Bay in the Straits of Juan de Fuca, Washington, and also to supervise a survey by Captain George Eaton of the beds from San Diego to Cedros Island, Mexico. During the

following summer, Doctor T. C. Frye investigated the beds of Southeast Alaska, and Doctor G. B. Rigg those of Western Alaska along the Aleutian Islands.

The survey in 1912 necessitated a 48-day trip covering 3,000 miles. It was made from the auxiliary yacht Paxinosa, owned by Col. Rader of Point Loma, and chartered for the occasion by the Department of Agriculture. Actual work of recording was found to be possible only from daylight to noon as at that time the sea usually became too rough for accurate observation, a fact which necessitated anchoring in many exposed places where uncomfortable seas had to be ridden and rocks, barely awash, to be shunned. Fortunately, only one storm of any severity was encountered, but that one necessitated the piloting of the Paxinosa out of Coos Bay, Oregon. The pilot, Captain Johnson of Marshfield, and his entire crew lost their lives two months later in a similar storm on that coast.

In addition to making charts of the kelp beds, studies were made of the methods of growth, the character of the bottom where kelp was found, the prevailing direction of winds and currents, and the availability of harbors for industrial plants.

Owing to the cost of printing the charts made, it looked for a time as though the reports of the various surveys would merely be filed away in the archives at Washington. It was through the efforts of the Honorable William Kettner, one of whose speeches before the House of Representatives appears in the Congressional Record of July 25, 1914, that the data were finally published in Senate Document No. 190 of the year 1912, and in Report no. 100, 1915, of the Bureau of Soils.

From Cedros Island, Mexico, to San Diego, kelp beds were found measuring 91.36 square miles, containing an amount of kelp estimated at 17,000,000 tons; from San Diego to Point Conception 97.92 square miles, estimated at 18,000,000 tons; from Point Conception to Neah Bay, 36.24 square miles, estimated at 4,000,000 tons; in Puget Sound 5 square miles, estimated at 520,000 tons; and along the Alaskan coast, 160 square miles, estimated at 18,000,000 tons. These figures are found, at the present time, to be too high, for reasons that will be explained later.

The kinds of kelp found were Macrocystis pyrifers, or common Ribbon Kelp; Pelagophycus parra, or Elk kelp; and Nereocystis leutkeana, or Bull kelp. Macrocystis pyrifers is found from the Gulf of Lower California to Sitka, Alaska, but occurs most extensively between Cedros Island and San Francisco. All kelps belong to a low order of plants known as the Phaeophyceae or Brown Algae, and are comparatively simple in structure. The three species mentioned above are sometimes called Giant Kelps.

The Macrocystis pyrifera, which is a perennial, grows from a holdfast varying from 3 inches to two feet in diameter, and attached to rocks on the bottom of the ocean at depths of twenty to eighty-five feet. It grows as a group of unbranched stipes which resemble in form the stems of plants of higher orders, and which vary from one-half inch to three-fourths of an inch in diameter at the bast and from twelve to one hundred in number. Bulb-like processes and lamina, or leaves, are given off laterally from these stipes at intervals of two feet

near the base but decreasing to one inch near the surface, where the free ends float out upon the water oftentimes for more than twenty-five feet. There are two methods of reproduction: one, by means of [illegible] from which new plants spring, and the other by means of dormant stipes which are located near the holdfasts and which begin to grow when the dominant stipes are injured or broken off. The growth of the indivisual stipe is by means of the splitting of a terminal leaf, the proximal portion of which forms new bulbs and lamina, while the distal portion continues to grow and split until the stipe has reached its maximum length.

The plant grows upon rocky bottoms free from much shifting sand, in regions of strong ocean currents and considerable wave action. It is not found along sandy beaches or, extensively, along the lee sides of islands but rather along exposed coasts. A large number of macrocystis plants growing together form the beds which one sees off Point Loma and La Jolla.

Pelagophycus porra is also found from Cedros Island to Point Conception, but not in such large quantities as is the Macrocystis. It, too, is attached to the rocks by a hold-fast from which springs a single stipe from one-half to three-quarters of an inch in diameter at the bast. Near the surface of the water this stipe becomes enlarged to a diameter of six to eight inches, and from its distal end there is developed a pneumatocyst or bladder; and from the distal portion of this pneumatocyst spring two prongs having a spread of ten feet in the older plants and considerably resembling elk horns. From the tops of these prongs grow lamina which are about two feet wide and from twenty- to twenty-five feet long, there being, usually, ten or twelve large leaves on a fully developed plant. Pelago-

phycus porra is an annual, producing its spores from sori, or small bodies on the lamina, and young plants developed from these spores may be seen floating in the water along the coast during the months of July and August. The value of Pelagophycus porra is limited, at present, to its use in making curios. It does not occur in sufficient quantities for the making of potash or fertilizer.

The third species observed, Nereocystis leutkeana, is found at intervals along the whole coast from Point Conception to the westernmost portion of the Aleutian Islands. In general characteristics this plant is similar to Pelagophycus Porra. Its lamina, however, are produced directly from the pneumatocyst, and its growth is more abundant, larbe beds being found which are composed entirely of this kelp. From Point Conception to Puget Sound beds of both Macrocystis and Nereocystis appear but, usually, not close together, whereas the species Pelagophycus porra, where found, is usually on the outer edge of a bed of Macrocystis. The reason for these conditions is not yet apparent. Nereocystis leutkeana occurs in sufficient quantities so that it may be used as a source of potash, but at present its use is confined to the making of curios, and to a limited extent, the making of an article of food called "seatron", much like citron in appearance but capable of being flavored as desired. It has also been made into a sweet pickle similar to that made from the rind of watermelon, and the bulb of the plant is used by the Indians about Fort Ross in making soup. Nereocystis is an annual, reproducing in much the same way as Pelagophycus, its spores ripening about the first of July, and for this reason the harvesting of it must be limited to a period beginning about the middle of

July.

The chemical analysis of kelp reveals potassium salts, and iodine and nitrogen in quantities sufficient to make them commercially valuable. The potassium salts obtained are in the form of chlorides and sulphates, and these are used in the various balanced fertilizers. Eight tons of wet kelp may be reduced to one ton of dry kelp, and this ton of dry kelp will contain from 12 to 13 percent, or 240 pounds, of potash, but in the form of potassium chloride or potassium sulphate. Iodine to the amount of .23 of 1% or 4.6 pounds will be found; and nitrogen to the amount of 1.57% or 31.4 pounds.

The first company to enter upon the handling of kelp on a commercial scale was the Coronado Chemical Company at Endinitas. It attempted to produce by a secret process a substance containing soluble potassium salts and phosphates together with certain other substances. Shortly afterward, the Ocean Products Company erected a plant at Half Moon Bay, but these two companies soon united and formed the American Products Company with their plant at Long Beach. Thereupon a number of companies sprang up whose main object seemed to be stock-selling, and whose principal way of using funds seemed to be overhead expense, with little actual money put into the development of the kelp industry.

The outbreak of the European War, however, turned the attention of large fertilizer and chemical companies to finding in the United States sources for the pot ash which for many years had been supplied from the Stassfurt mines of Germany, the United States having imported over 900,000 tons of potash salts per year, at a value of over$12,000,000. Investigations were consequently started in many directions, but it was to the kelp

of the Pacific Coast that the big companies turned. Swift and Company of Chicago leased the Kelp Products Company's plant at Roseville for a series of experiments, the results of which led to the establishment of a large plant at the foot of G Street, with a big battery of driers and a harvester capable of carrying 500 tons of wet kelp. The Hercules Powder Company at about the same time began the establishment of what is now the largest potash plant on the Coast. The Kelp Products Company continued their plant as a producing one after the lease of Swift and Company had expired.

In addition to the companies using machinery, there has sprung up a considerable group of handpickers. These established themselves where kelp can be easily picked up along the beach or readily landed in skiffs. They hang the kelp on wires to dry and then burn it to obtain the salts.

North of San Diego there are seven kelp companies in existence and one under construction. The total capacity of the companies outside of San Diego is 950 tons per day, while that of the San Diego companies is more than 2,000 tons per day.

Kelp is cut by means of a device similar in principle to the haymower, and after being cut is caught upon a draper which carries it up into a barge. Some companies favor cutting the kelp into small lengths as it is received upon the barge, while others wait until it is taken to the plant.

These harvesters, theoretically, cut to a depth of six feet, but, practically, they seem to be cutting to a depth of only three feet. The capacity of the harvesters varies from five or six tons per hour to sixty tons per hour.

The beds being utilized at present comprise only one-fifth of the area surveyed between San Diego and Point Conception, and one-twentieth of the area on the west coast of North America. The plants located at San Diego are cutting four-fifths of the total amount cut. The practical results of the harvesting show that about ten per cent of the estimated amounts is actually being harvested. The difference is due, first, to probable over-estimation of the quantities in the beds; second, to the changing of the beds; third, to the fact that not the entire amount cut is harvested, and that a certain proportion of the plants are injured and die back, and fourth, to the fact that currents draw the kelp under water away from the reach of the harvester which must be operated regardless of the tide. Besides, rocks often hinder cutting.

In addition to using kelp as a fertilizer, processes have been developed whereby the salts obtained may be used in making substances necessary for the manufacture of matches and also of munitions. This fact has brought about the development of two distinct types of plants, the one handling the kelp wet, and the other, dry. In the dry process large rotary driers are used, which are from five to six feet in diameter and thirty to forty feet in length, and which resemble cement kilns. The wet kelp is placed in the heated end of the drier and passed out of the cooler end. It is then put through an incinerator, ground and sacked. At present this process loses, in the smoke, the iodine and the ammonia generated, but methods are being worked out whereby it is expected that these by-products will be saved. In the wet process the salts in the kelp are removed by solution and thrown down by crystallization.

With the exception of the kelp, no great sources of potash salts have been discovered in this country, although considerable quantities may be gotten from certain waste products, such as wood-ash, and from certain bitterns such as those found in the Searles Lake district.

That it is important for us to develop our kelp industry wisely will be seen if one thinks what a permanent embargo on the exportation of potash salts from Germany would mean to the farms of the United States, upon which, in the past, have been placed nearly 900,000 tons of potash salts per year as fertilizer. Furthermore, in case of war, a domestic supply of potash and acetone would be absolutely necessary for the manufacture of munitions; and iodine, which heretofore has largely

come from Chile could be obtained at home.

The situation requires careful study of the effect of cutting upon the beds themselves; upon the adjacent shore-lines; and upon other industries. Enough evidence is at hand to show that during the summer months the beds replace in less than ninety days the portions cut to the depth of six feet; that cutting the kelp takes off the heavy surface layer which is normally torn away to a greater depth during heavy storms and lost; and that, while somewhat reducing the surface resistance, cutting does help to make the deeper breakwater more permanent. As the kelp is cut not more than six feet below the surface of the water, it has no bad effect upon the fishing industry, either as regards fishing-places or spawning-grounds. Investigations of this matter have just been made by the U.S.S. Albatross of the Bureau of Fisheries, and their report is that never in the history of albacore fishing has bait been more plentiful than it has been this year.

In 1914 legislation was proposed for the conservation of the kelp beds, and was introduced by Senator E. A. Luce and Assemblyman Grant Conard. This legislation failed because of a misunderstanding between those interested in the kelp industry and those proposing the bill. At present a bill is being prepared which would place control of the beds in the hands of the Fish and Game Commission, giving them power to apportion and patrol the beds, and to make such regulations as will conserve the beds and give equal opportunity to all legitimate concerns.

Furthermore, $175,000 has been set aside by the United States Government for investigations to be conducted by the

Bureau of Soils in order to determine the best methods of handling kelp for commercial purposes.

The Scripps Institution for Biological Research is interested in the life-history of kelp and in its conservation for the best interests of all the people.

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During the year just past, the maximum quantity of Kelp that could be practicably obtained form~~t~~ the Kelp beds of Southern California has, for the first time, been harvested. Previous statements concerning quantity or extent of beds have depended on estimates or on cuts made during limited periods of time. The following table shows the percentage of Kelp harvested near San Diego;

Location	Estimated area	Quantity harvested 1917	Gov't Estimate 1912 3 ft.deep-1 cut per yr
Pt. Loma	5.4 sq.mi.	115,765 tons	251,100 tons
La Jolla	2.3	35,483	113,450
DelMar-SanJuan	4.63	34,415	171,045
SanPedro-Redondo	2.66	(1916) 49,070	123,690

The total quantity harvested this year is approximately 375,000 tons while the governments estimate in 1912 was approximately 2,200,000 tons or in other words, the amount practicably harvested ~~cut~~ is only 17 per cent of the government estimate. It is a recognized fact that, in harvesting, a considerable amount of kelp is cut and allowed to drift away from the harvesters, estimates of this amount running from 20 to 50 per cent but the estimate usually accepted being about 43 per cent. This would make the amount that it is possible to harvest from the beds actually about 25 per cent. Furthermore, certain portions of most of the beds can not be harvested on account of the presence of rocks. The companies that have entered the industry did so relying on the government's estimate of the quantity of kelp available, and the result has been that they have not found the supply adjacent to their plant-sites adequate for their needs and have had to harvest at much greater distances, in some cases at distances of more than 100 miles.

At various times during the fall of 1916, meetings were held which were attended by those financially interested in the Kelp Industry and by representatives of the State and Federal Governments. Their purpose was to draw up a legislative bill definitely placing the Kelp beds of our Coast under proper State control in order to insure their conservation. As a result of these conferences, the State Legislature passed a bill placing the control of the beds with the Cal. State Fish & Game Commission, and assigning ~~the~~ to the Scripps Institution for Biological Research the task of continuing scientific investigation in regard to the Kelp itself. To provide money necessary for these projects, a privilege tax was levied which required the Kelp Companies to pay one and one-half cents per wet ton of kelp gathered, one cent of which was to go to the State Fish & Game Commission and one-half cent to the Scripps Institution. After the passing of the bill, rules and regulations for cutting were drawn up in accordance ~~fre~~ with the information which had been gathered from the practical harvesting already done. It was apparent from that experience that the beds should have from 2 to 3 months'rest after each cutting, therefore some of the beds were then declared closed ~~while~~ for a definite period. In order that the beach resorts might not be inconvenienced during the summer tourist season, the beds adjacent to them were closed for that period and opened for harvesting ~~during~~ later.

The Fish & Game Commission issued a set of maps with the positions, numbers and names of all beds south of Pt. Conception, beginning with Tia Juana Bed #1 and proceeding in order to Pt. Conception Bed#3 ,thence back about the Islands to Smuggler's Cove#45 off San Clemente. Copies of these maps are issued to all concerned in the matter so that orders for opening or closing beds are easily given and readily understood. Certain beds are closed indefinitely as those near Summerland which the Federal Government is using in its experimental plant at Summerland. A portion of the bed off Santa Barbara is also closed owing to the intense distrust of the people of that region as to the effect cutting would have on their beach boulevard.

For the present the beds about the Islands have not been closed as it was

thought best to allow the companies to harvest there while weather conditions permit, especially since weather conditions there can be depended on to prevent excessive exploitation of the beds. On the other hand, definite orders were given in regard to the beds along the coast line, the periods of opening and closing being explicitly marked.

The good effects of such control are already apparent in the fact that beds so treated show an increased tonnage yield. The companies themselves are now able to work in greater harmony since the regulations affect them all.

Due largely to the distribution of the beds along the coast, the Kelp Industry has sprung up in three distinct centers, San Diego, Long Beach, and Santa Barbara, and there is a general supposition that the companies will use the beds nearest them, thus the ~~San~~ understanding is that the San Diego companies will work from Tia Juana to Laguna along the coast, and about San Clemente and Saint Nicholas Islands; that the companies of the Long Beach district will work from Pt.Fermin to Ventura along the coast, and about Santa Cruz Island;and that the companies of the Santa Barbara district will work from Ventura to Pt. Conception. This is the practical way of dividing the territory since it lessens the cost of harvesting, and while all open beds are open to all, this division of beds has, for the most part, been recognized in fact by the companies as a gentleman's agreement.

A botanical study of the kelp has revealed facts regarding its growth which determine the time for opening a bed after its resting period. Shortly after a bed has been harvested, a young growth appears, light olive-green in color and having delicate, dividing tips.After a period of from 30 to 60 days, these plants are found to have spread out on the surface of the water, their color to have changed to a dark brown, and their growing tips to have disappeared. In other words, the plants are found to be mature, and when the majority of plants in a given bed are in this stage, the bed is at its best for harvesting, both as concerns the bed itself and the companies interested. If allowed to grow longer, the plants darken in color and become incrusted with little animals of a very low order, namely bryozoans, and somewhat later with small,white, worm-tubes. At this juncture the kelp begins to rot, a fact

which accounts for the masses of kelp formerly found along the beaches. If the plants are cut before this period the amount of rotted kelp washed ashore is lessened and the beaches , except during the period of harvesting itself, are cleaner than before.

Another good feature of the proper harvesting of kelp is that during heavy storms the plants are not so badly torn up from the bottom since the surface resistance is lessened by the removal of the thick mat at the top, and a greater mass of submerged stems and branches remains to protect the shore-line.

Dr. R.P.Brandt, botanist at the Scripps Institution who has been studying the early development of kelp, has found plants fruiting during the entire period from September 1917 to the present. This fruiting appears as darker brown, irregular blotches on the leaves, and these blotches are seen to give off spores from which new plants develop, but whether directly or by a complex process is not yet known. At any rate, it is apparent that the plants are continually reproducing themselves.

During the last summer and fall a heretofore unnoticed condition occurred which caused consternation to those interested in the kelp industry. First a black rot appeared on the plants in some of the beds, on the leaves first and then the stems and finally the plant would disappear. The beds along the coast were practically depleted by it for a time, but fortunately the condition did not prevail for long. In some of the beds not attacked by the rot, however, some other condition arose which caused whole beds to suddenly disappear. Great quantities floated ashore and out to sea. Whether this was a natural process ~~in the~~ related to the age of the plants, or whether the unusually high temperature of the coast waters, the absence of northwest winds and the lack of the usual upwelling of colder water were responsible for the condition, is a matter of conjecture. An interesting and encouraging feature of the case was that the beds which had regularly been harvested were not so badly affected as those which had never been harvested, an instance being the beds off Santa Barbara. They had never been harvested and yet they practically disappeared.

In the southern waters there appeared during the same summer, large ~~num-bers of~~ areas of "red-water", so-called because the presence of billions of certain microscopical animals or plants makes the water look red. It is possible that the unusually large numbers of these had some thing to do with the rotting of the kelp but not enough observations in past years are at hand to permit of such a conclusion. In fact there is much to learn about this whole subject but the outlook is encouraging. The commercial companies are solving many of their difficult harvesting problems and the research men are doing valuable work while the State is watching to see that its resources in the Kelp beds are ~~properly~~ used properly and in a manner fair to all.

"Fishermen Possibly 1-22-19

THE ECOLOGY OF AMERICAN ECONOMIC KELPS.

Introduction.

The tremendously increased demand for commodities of all kinds that arose during the Great War is now a commonplace of all economic discussion. Nowhere, perhaps, was the pinch felt more severely than in the commercial fertilizer business. On the one hand rose the cry to the farmers for greater production, which of course meant, among other things, a greater use of fertilizers. On the other hand, the producer was confronted with an unprecedented shortage of one of the most important classes of fertilizer materials. The Stassfurt potash fields were cut off from all but the Central Empires, and all other operating sources of potash in the world put together could not satisfy even a tithe of the need.

This great unsatisfied demand for potash naturally stimulated the investigation of possible new sources of supply, and to some extent led to attempts at their exploitation. Reduction of feldspathic minerals, mining of certain saline deposits in Kansas and several other western states, and the production of potash salts from the ash of certain plants of the Utah-Nevada desert were some of the schemes proposed. But the field of most promise, and the one most extensively exploited lay in the great beds of giant seaweed, or kelp, along the Pacific coast of the United States, notably off the coast of southern California.

Although the production of potash salts and other useful substances from seaweed was practised here for the first time along modern industrial lines, it was not a new thing, but rather an extension of an industry of considerable antiquity. Seaweed

has been used for fertilizer by men along the Atlantic shores of both Europe and North America for many generations. While it was largely used by the farmers who gathered it, being either dumped directly on the soil and plowed under, or first burned and the ash used, kelp at one time had some importance as an article of commerce, being the main source of iodine and one of the sources of the alkali salts needed in soap and glass making, before the discovery of the cheapn manufacture of sodium carbonate out of common salt.

It may be worth while to give a passing glance at the confusion that apparently obtains in the usage of the word "kelp". The Encyclopedia Britannica gives: "Kelp, formerly <u>kilp</u> (M.E. <u>culp</u> or <u>culpe</u>), of unknown origin . . . The ash produced by the incineration of various kinds of seaweek obtainable in great abundance on the west coasts of Ireland, Scotland and Brittany," with the further note that its importance in industries passed with the introduction of the cheap manufacture of soda from salt. The other encyclopedias, even the Americana, copy the statement without variation. "Kelp" as a name for seaweed is not even mentioned.

There is, however, no question as to the meaning of the word in the United States. In the writer's own experience on both coasts, with a number of competent botanists as well as with seafaring men and men interested in the commercial exploitation of seaweed, "kelp" has always meant seaweed, and in particular large seaweed. The Century Dictionary defines "kelp" both as the plant and as the ash, giving the plant the first position. Webster's likewise lists both definitions, but gives the ash the precedence. Murray's English Dictionary lists both, giving

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the first plant, and quoting Trevisa, a fourteenth century author:

"As culpes of the see waggeth with the water",

and also Darwin (Voyage of the Beagle). Samuel Johnson, however, lists the word only as meaning the ash. The situation seems to boil down to this: The earlier usage recognized "kelp" as meaning the seaweed. Later, when the practice of burning assumed importance, the meaning was extended to include the product. Then for a time the product only was meant, and finally we have a return to the original meaning, with the name for the ash holding only a secondary and obsolescent place.

But even when the legitimacy of "kelp as a name for seaweed is established, there still remains a good deal of looseness and uncertainty in its application. It is sometimes used as a name for all seaweeds without distinction, but there seems to be an increasing tendency to apply it only to the giant brown algae of the deeper littoral zones, and to refer to the smaller inshore flora as "rockweed". Sètchell makes kelp=Laminariaceae, and rockweed=Fucaceae.

There are several Pacific American species of the Laminariaceae whose size and depth-position entitle them to consideration as kelps. Of these the most notable are *Alaria fistulosa*, *Nereocystis luetkeana*, *Pelagophycus porra* and *Macrocystis pyrifera*. These are the kelps considered in greatest detail by Cameron and his associates in their reports of 1912 and 1915, and suggested as the ones most likely to be worth commercial exploitation.

Alaria consists of a stout, hollow central axis, with a maximum length of about forty feet, which acts as a float, and from the sides of which projects a great flat blade or lamina.

Near the distal end, the edges of this lamina are commonly split and shredded out, like the leaves of a banana tree, whence the common name "stringy" kelp. Unlike the other three kelps, which bear their spores in sori on the vegetative laminae, Alaria has a group of special sporophylls at the base of its one main lamina.

Nereocystis, the "bull" or "bladder" kelp, and Pelagophycus, the "elk" kelp, are quite similar as regards their anchoring and floating organs, differing only in the manner of the attachment of the laminae. In each there is an anchoring mass of rootlike holdfasts; a long slender ropelike strand extending from the holdfast to the surface, at its upper end becoming expanded and hollow; and surmounting this a hollow spherical float or pneumatocyst, which is sometimes as much as a foot in diameter. The laminae of Pelagophycus are great ovate-lanceolate blades ranging from one to three feet in width and in length from five to fifteen. They are attached to the top of the pneumatocyst by a pair of branching, antler-like stems that suggest the common name "elk" kelp. The laminae of Nereocystis are of about the same dimensions as those of Pelagophycus, but are less definitely ovate in shape and attached to the top of the pneumatocyst by very short dichotomous stems; so short indeed as to give rise to the common impression that the laminae are sessile.

Macrocystis, "ribbon" kelp or "California" kelp, sends up from its holdfast a long, ropelike stipe which bears at intervals alternately-arranged, serrate-margined, lanceolate laminae, each from three to six inches wide and from eight to eighteen inches long and provided at its base with a small, pearshaped pneumato-

cyst. Presumably the specific name pyrifera refers to these structures. While Macrocystis has no specialized sporophylls, like those of Alaria, certain of the laminae near the base of the stipe become somewhat modified and produce most of the spores. A second region of higher sporulation sometimes develops at the distal end of the frond.

The respective modes of growth of the four species differ as much as do their forms. In Alaria the region of growth is confined to the base, apparently just above the group of sporophylls. The plant is perennial, but its rate of growth is not known. In Nereocystis and Pelagophycus the growth seems to be confined to the base of the laminae. Both of these plants are believed to be annuals, although cases of survival through more than one season have been reported. Macrocystis is a perennial, and differs from the other three in two particulars that have determined it as the most profitable species from a commercial point of view. The first is that it is apical and indeterminate in the elongation of its main axis, a great accumulation of surface growth thus being possible. The second is that whereas the others produce only one stem from the holdfast base, Macrocystis "stools out" like wheat, producing a number of suckers or stolons. These stolons are not started all at the same time, so that a given plant will have perhaps six to ten of them in all stages of growth. Contrary to the once commonly accepted belief, a stalk once cut off does not continue to grow, but slowly dies back to the holdfast; in the meantime, however, one or more of the younger stolons grows out to take its place. This makes three or four cuttings a year possible in the Macrocystis beds, while the annuals Nereocystis can be harvested only once, and that with

the nicest care lest it be taken before it has shed its spores and the next year's crop thus ruined.

The foregoing brief description summarized our knowledge of the natural history of these species at the time (about 1910) when the Department of Agriculture initiated its survey of the fertilizer resources of the United States. The workers in this survey, and a number of independent invesitigators, speculated and experimented a great deal with all manner of things, in addition to the obvious potash and iodine, that might be made from kelp. Naturally, foor for human beings was one of the first things thought of. For many centuries the Japanese have used seaweed preparations. The agar of our laboratories is, as everyone knows, a Japanese kelp product. Other maritime peoples have used marine algae as a food also, though to a lesser extent. However, a few experiments sufficed to demonstrate that there was little available protein in kelp, and that the carbohydrates were largely complex polysaccharids of low digestibility.

There was also some experimentation with the direct application of ground dried kelp to the soil. It was found that to get the best results from such use of kelp it would have to be applied wet--a proceeding of course not to be thought of except on fields immediately adjacent to the coast.

A large part of the kelp is made up of a mucilaginous substance (or more properly, group of substances) called "algin", which yields an"alginic acid", forming salts with bases. One investigator made alginates of about all the metals there are, but could not suggest a practical use for any of them.

During this trial-and-error period numerous projects were launched for kelp-products companies. Some of them were mere stock-jobbing concerns which never harvested a ton of kelp or anything else than their investors' money. One or two, however, were making modest headway, mostly offering ground kelp in the local market. Experiments with mechanical harvesters resulted in the adoption of something like a giant grain reaper mounted on the front of a barge, with means for hauling the kelp up and transferring it to scows for transport to the plant on shore. It became evident that for the proximate future little profit could be expected from the _Nereocystis_ beds in the Seattle region, and developments tended to base themselves on the _Macrocystis_ of southern California, centering around the San Pedro region and in San Diego Bay. And most important of all for the development of the industry, the federal government established an experimental plant at Summerland, California, to develop if possible means of obtaining some product in addition to potash, for with the then low price of the German product there was no chance for competition in that commodity alone.

Then came the war. German potash disappeared from the market and the price went to about six times its former figure. Kelp potash now was profitable and more than profitable, and developments took place accordingly. Local plants boomed, new ones came into existence, and eastern concerns built big establishments of their own. Notable among these were the potash plants of Swift and Company at San Diego and of the Diamond Match Company at San Pedro. The Hercules Powder Company built a plant near San Diego for the production of acetone, with potash and iodine as by-products. All the other plants simply incinerated

the kelp for the potash and iodine. The capital invested ran well into the millions, with corresponding payroll outlay, and, of course, proportionate profits. There was not enough kelp to satisfy everybody, and a kelp administrator had to be appointed to reconcile conflicting claims, allot to each company its proper share of the beds, and prevent destructive harvesting. From 1916 to 1918 the kelp business was at its peak. The total weight of kelp brought in during 1916 was 134,537 wet tons; during 1917, 394,974 wet tons; during 1918, 390,863 wet tons.

The cessation of hostilities struck the kelp industry like a blight. Without even waiting for a shipment of Stassfurt potash to leave Germany every plant shut its doors, junked its machinery, and went out of business. The decline of the industry was even more rapid and spectacular than was its rise; it was more like a collapse. Only the government experimental plant at Summerland continued in operation. The need for its activities was now greater than ever, for it was now more than ever evident that if kelp was to be utilized at all some use must be found for the organic constituents, which most of the wartime plants had simply been sending up the chimney. During the past year a process has been perfected for obtaining a high-grade clarifying charcoal, at the same time recovering all the potash and iodine that the old processes yielded. A new firm is being organized in San Diego which will undertake to manufacture commercial products by this process.

Thus we come to the end of the first, and perhaps most romantic, chapter in the story of the American kelp industry. The imperative wartime drive and the reckless long purse of wartime demand are gone. The new chapter now beginning will be

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a more commonplace affair, or close figuring of costs and profits, or expansion on the basis of normal profit only, of efficiency engineering and the study of the nice balance between maximimum allowable exploitation and necessary conservation. For all these, exact knowledge of all of the factors of the enterprize is necessary, and not the least of these necessities is the accumulation of data on the raw material itself. This paper toes not pretend to offer any real data at all; one of the most discouraging things about its preparation has been the disjointed and incomplete nature of the data now available on the natural history of these kelps, the lack of knowledge of the factors conditioning their lives, and through them the success or failure of the industry. It is rather the attempt here to gather and arrange such information as is available, and to indicate some of the gaps that must be filled before we may regard ourselves as masters of the situation from either the scientific or industrial point of view.

General Ecology.

In the consideration of the ecology of a group of plants that resemble each other in some respects but differ in others, it is obviously the sensible course to consider the group as a unit insofar as the resemblances extend, and beyond that to examine in detail the problems of each species separately.

The several species making up our group resemble each other in that they are all brown marine algae, with holdfasts that anchor them to substrata in relatively deep water, with slender stipes that moor their sufaces masses of vegetation supported by floats or pneumatocysts, and in a number of important physical require-

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ments which they make of their environment. They differ in their geographic range, in the depths at which they occur, in the density of their stands or beds, in their growth habits and fruiting seasons, in manner of reproduction, and in a number of responses to their environmental conditions.

Taking first, then, the group as a whole on the basis of mutual resemblances between its members, we find a long series of beds of marine vegetation, extending from western Alaska to central or southern Lower California, in depths of from one or two to eighteen or twenty fathoms of water. One of the first things we notice is that the formation exists as a series of beds, and not as a continuous belt. Since all of the species sporulate very freely and are of rapid growth it is safe to assume that they will be everywhere that they can grow at all, and that their continued absence from a given place is an indication of arrival at some limiting factor in the environment--that some condition or group of conditions necessary for the development of the plant is absent.

Now, the conditions necessary for the normal development of a kelp plant are essentially the same as those required for the normal development of an independent-living, chlorophyll-bearing plant on the land. They include mechanical support, supplies of water, oxygen, carbon dioxid and the essential mineral salts, the requisite degrees of temperature and insolation, removal of excretions, and freedom from overwhelming attacks by natural enemies. Where all these are present the plants will flourish; where one or more is absent, or is present either subminimally or supermaximally, no growth will take place. If, then, we compare conditions where kelp flourishes point by point with conditions

where it does not, we shall be getting materials for a complete picture of its ecological requirements.

One general proposition worth bearing in mind as we attack our problem is the tremendous difference between the media through which the life-factors are brought to bear on land and water plants respectively. Land plants are influenced through three media, water plants through only one--if we except the higher fresh-water aquatics which are after all land plants that have taken again to the water. Land plants as a rule derive their external mechanical support, their mineral salts, and possibly even part of their gaseous nutriment, from the soil, which is a three-phase complex of solid, liquid and gas. Through the air, which is a gas, they receive the bulk of their oxygen and carbon dioxid. Their aerial parts receive also solar energy. Temperature is affected through both soil and air.

But with the marine alga practically everything is controlled by the water. The soil (usually a solid rock) contributes only an anchorage, and the laminae that float on the suface must not be exposed to the air, else they dry up and perish. The water, then, is almost _factor_ _fac_ _totum_ to the seaweed, and its effects on other life-conditions are far-reaching indeed. When we observe the odd picture of a lusty plant like _Nereocystis_, with a north-and-south range extending from the Aleutian Peninsula to below the Golden Gate, limited to an east-and-west range of a few hundred yards at most, while many adjacent land species extend eastward clear across a continent, we have pretty vivid evidence of the potency of water as a limiting factor in one direction, and as an extending factor in the other.

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Because conditions in the world of water are so greatly

different from those in our more familiar cosmos, it will perhaps be worth while to take up our examination of the general ecology of the kelps largely from the aquatic point of view: to consider in detail the influence exerted by water upon each of the other life-conditions as roughly outlined above.

We shall consider water, then, first as an influence on mechanical support. The aerial parts of all land plants are a pressure of approximately one atmosphere, and this is all the resistance they have to adjust to in the mechanical functions of their cells, such as transpiration, the maintenance of turgor, and so on. Under water, however, the pressure increases at the rate of about one atmosphere for every five fathoms. Thus the osmotic functions of algae must be adapted to pressures that vary with the depth, and the structure of the pneumatocysts must be adapted to crushing pressures also. So far as the writer is aware, no attempt has been made to find the breaking point ofthe latter structures. Many experiments have been made with the osmotic values of algae, which indicate a larger back-pressure than that necessary to offset the combined effects of depth-pressure and chemical concentration of sea-water. Since our giant kelps grow in water as much as twenty fathoms deep their tissues must be adapted to pressures ranging from one atmosphere at the surface to about five atmospheres at the bottom; and when they first come into existence they must be adapted to the maximum pressure. Whether this in itself is a limiting factor in vertical (and hence in lateral) distribution is not known; probably it is not, as suggested above. Still, the adjustment of kelps to pressure is one of the things we know little about; it is the first of the gaps waiting to be filled.

In addition to the static pressure, we must also consider the strains due to the motion of the medium. Since the density and viscosity of water are many times that of air, much lower rates of flow will result in higher strains. Wind frequently causes damage to land plants at velocities of about fifty miles per hour. Against a normal surface this is equivalent to a pressure of eight pounds per square inch. To give an equal pressure, a water current of only slightly over two miles per hour is necessary. No data on rates of shore and tidal currents are available, but this velocity must be reached or exceeded in many places where kelp grows. This discussion of course omits any consideration of skin friction, which is naturally much greater in water than in air currents. Moreover, so far as the writer knows, no calculation has been made of the force of ocean waves, but this must be very great. For reasons presently to be considered, the kelps demand locations of vigorous wave or current motion, but they must none the less be adapted to resist the tendency to break or dislodge. Any organism standing stiff like a tree would be broken off or uprooted in very short order, but these plants, with their strong anchoring holdfasts, their long, ropelike stems, and the general streamline shape of all their organs, are well fitted to trail out in the direction of least resistance and ride out storms and spring tides.

As already mentioned, one of the notable things one any map of the kelp beds is the discontinuity of the kelp forest. These gaps are related to the mechanical pull of the water; here there is no doubt of the action of the water as a limiting factor. Kelp is found only over rocky bottoms, where the holdfasts can get a firm grip. It is not found off the mouths of silty rivers nor

off sandy beaches. Frye ascribes the breaking loose of the vast numbers of young kelp plants to their establishment as "sporelings" on sandy bottoms, whence they are pulled as they become large enough to offer more resistance to waves or currents. The occurrence of kelp in irregular strips and patches in certain places may well be due to the presence of rock outcrops in otherwise sandy or silty bottom. Bottom exploration by dredging or diving is needed to investigate the possibility of such correlation. In this connection it is also worth noticing Rigg's opinion that part of the destruction wrought upon the kelps by the eruption of Mount Katmai in Alaska was due to the covering of the anchorage rocks with a deposit of volcanic silt.

When we come to the effect of water on the second item in our random list of life-conditions, we arrive at an apparent paradox. How can water affect water? We can approach an answer by recalling another paradox, the old one, that even land plants are physiologically aquatics. Every living cell in the land plant must be kept moist. All materials coming in or going out must pass through a wet membrane, just as they do in the simplest algae. It is to maintain this water-soaked condition of the aërial parts that the elaborate water-conducting system of land plants must be maintained, and it is mainly to obtain water from a medium often reluctant to yield it that the far-reaching root system must be developed. It is different with the kelp. With water one hundred per cent. available about all parts of the plant, the struggle of the latter to get a living out of its environment is considerably simplified. Eighty-five or ninety percent. of the body of the kelp is made of water, its

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limp length is floated up by water, everything it needs in its life processes comes through the water, all its excreta are carried away by the water, its spores are distributed and nursed by the water; why should it bother to develop any special organs for absorption, translocation, transpiration and all the other troublesome functions that the flesh of vascular plants is heir to? Might as remain a kelp. If water places narrow limits on life, it makes life within those limits very easy. Water, that great wet-nurse of us all, has played special favorites with the big kelps; no wonder they have in most things remained big babies.

A third condition for plant life consists in a supply of the necessary mineral elements, calcium, magnesium, potassium, sulphur, phorphorus and iron. To these must be added in the case of our kelps, three elements usually found in them in appreciable quantity, sodium, chlorine and iodine. The presence of sodium and chlorine is easily understood, considering their high concentration in sea water. But one of the mysteries of kelp physiology lies in the relative high ratios of potassium and iodine found in kelps, as compared with their low ratios in the sea water. However, all one can do for the present is put the responsibility on "selective permeability of the protoplasm", or some such formula.

But whatever may lie at the bottom of the riddle of internal algal physiology, it is evident that the influence of water is in this case extensive rather than restrictive. Of course it is not necessary to dwell on the point already indicated, that the kelp is relieved of the necessity of providing special organs of absorption and circulation by the fact that the medium provides all the circulation necessary, and that all the tissues may be

absorbent. It is less obvious, though still apparently true, that the amounts of mineral food materials at various locations and different depths are safely within the necessary limits. While the density and salt proportions of sea water change with great depths, the waters we are concerned with are too shallow to be affected by the factors causing these conditions; moreover, the constant shifts and churnings of currents, tides and waves close inshore tend to maintain uniform conditions.

The kelps, however, seem to be sensitive to changes wrought by discharges of rivers, and are not found in zones where the salinity of the water is permanently and materially reduced. There is, of course, the possibility here of influence of sewage and other contamination, as well as the mechanical difficulty of silt deposits mentioned above.

The fourth and fifth of the life-conditions, oxygen and carbon dioxid, may as well be considered together, since they both occur normally as gases, and are therefore affected in much the same fashion by the water. Since they must be brought to the kelps in solution, like the mineral salts just considered, it mig might seem that they could have been treated under the same head; but there are several reasons for taking them separately. In the first place, being gases, they behave differently in solution, tending constantly to escape, especially under conditions of rising temperature. Again, both are absorbed by the kelps in much greater quantity than are the minerals. For these two reasons their supply must be constantly renewed, if the kelps are to grow; hence probably the limitation of kelp beds to locations constantly washed by waves or swept by strong currents. It is thus evident that the influence of water on the gaseous components

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of kelp environment is restrictive rather than expansive. Whether depth of water affects the gas content to any such degree as does movement is a thing as yet unknown. On the Southeast Alaska expedition Frye carried apparatus for the determination of oxygen and carbon dioxid in the sea water. He reports no observable differences in gas content, either for location or depth. The possibility is worth noting that the difficulty with silts, mentioned once or twice above, may be chemical as well as mechanical; that is, deposits of silt may smother out spores and young plants. Whether a paucity in oxygen and carbon dioxid in deep and silt-free waters exists to a sufficient extent to limit the growth of sporelings cannot be more than surmised at. This is one of the points that might repay more critical investigation.

The great restrictive power of the water over other environmental factors is perhaps best displayed in connection with the light relation. Ecologists generally ascribe to differences in duration and intensity of illumination and in the composition of the spectrum, some causal relation to the great differences in life-forms and growth-rates of land plants at different latitudes and altitudes. The great influence of these relatively small changes wrought upon light by the atmosphere serve the more to emphasize the profound changes caused by water, and their correspondingly great influence on submarine plant life; for it is highly probable that the limits (or at least the lower limits) of the bathymetric distribution of the kelps are determined more by the effects of depth on light than by any other factor. However, the difficulty of determining the correlation between light and plant life at the

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depths inhabited by the kelp is greatly increased by two factors: first, the imperfect state of our whole knowledge concerning the light relationships of plants in general, and second, lack of satisfactory data on the light conditions of the environment we are studying.

We do know that the light relationships of plants are not simple, single phenomena, but that on the contrary they fall ingo several more or less distinct but closely correlated groups. Though not by any means the only ones, perhaps the chief among these are responses in photosynthetic activity (which underlies all nutritional processes), and in growth. In each, the light relation is complex, depending on (1) intensity, (2) duration and (3) spectral composition of the light. Furthermore, the optimum in light conditions for photosynthesis is not optimum for growth, though it is practically impossible to determine what is the optimum for growth, because growth is absolutely dependent upon nutrition and hence in the end upon photosynthesis. However, such analysis of the light situation as can be made under present conditions does disclose some interesting facts.

It is not apparent that there is any maximum for kelps in either intensity or duration (except in so far as temperature is indirectly involved), for the beds extend from the region of vertical insolation off Lower California to the region of the long arctic day in Alaskan waters. At least one species, Macrocystis pyrifera, is found throughout a great part of the range, and the limitations of the others would appear to depend more on factors other than light. Minima in intensity are fixed by depth; and it is here that the absorption of light by the water is most strongly operative in fixing the lower (and hence the outer or

seaward) limit of the range.

An examination of the manner in which water reduces the intensity of illumination shows at once that the phenomenon is by no means a simple one. To both plant and water, light is not at all what it is to the human eye. Different parts of the spectrum have differing effects upon plants, and different parts of the spectrum are absorbed at differing rates by water. It is well known that the rays most effective in photosynthesis of green plants are in the red end of the spectrum. Green algae are like green vascular plants in this respect. Due, probably, to the additional pigment, the brown algae conduct photosynthesis most efficiently under the influence of yellow rays; they can, however, make efficient use of red rays also. Red algae utilize the yellow-green region, but make no use of the red. The "zoning" of marine algae, from green through brown to red, as depth increases, is a long-recorded fact, and its correlation with the differential absorptive power of water for light waves of various lengths is an old assumption, although no exact observations have yet been made to prove it. The accompanying chart[1] will be

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[1]For most of the work done in calculating these curves the writer is indebted to Mr. Lloyd Taylor of the Physics Department of this University. The data are adapted from Ashkinass' figures, as given in Kayser: Handbuch der Spektroskopie, Bd. III. It should be kept in mind that these figures are based on absorption in fresh water. The writer has been unable to find any absorption coefficient for sea water. But in lieu of anything better, the present chart will serve for purposes of rough approximation.

of service in this connection. It will be noted that the red rays (800-600$\mu\mu$) are absorbed very rapidly, scarcely one per cent of the initial intensity at the edge of the orange section (650$\mu\mu$) remaining at 20 meters depth, while at the mean maximum for kelp (ca. 40 meters) they are practically extinguisned (.01 per cent. intensity). The orange rays fall off somewhat less rapidly, but even they are down to three per cent intensity at 20 meters, and to 0.65 per cent. at 40. The degree of absorption falls off sharply in the yellow region. Waves of 587$\mu\mu$ retain nearly 40 per cent. of the initial intensity at 20 meters and well over one per cent. at 40, while waves of 575$\mu\mu$ retain 67 and 45 per cent., respectively, at these depths. Since the latter wave-length is somewhere the optimum for photosynthesis in the Phaeophyceae, the excellent fitness of kelp for life in its zone is evident. There is light enough at 20 fathoms to enable young plants to grow, and when they reach the surface their ability to utilize the red rays gives them an added advantage. The limiting minimum of intensity would seem to be represented by the figures for 20 fathoms, or perhaps for a slightly greater depth. The kelp maps of Rigg, Frye and Crandall show no soundings in beds greater than 20 or 21 fathoms. The majority of soundings as great as this are off the California coast, and to a less extent in Puget Sound waters. As might be expected, the limiting depth becomes less toward the north; the lower intensity of light at the surface, together with its lower anble of incidence, would make for minimal conditions nearer the surface.

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anything in the doctrine that large doses of short-length light have a retarding effect on plants, one would expect the sporelings of kelp to suffer. But too little is known at present about this whole subject to make speculation worth while.

An important consideration is the question of nutritional conditions in the lower parts of the mature plants, where those important organs, the holdfasts, are; and in two species (Alaria and Macrocystis) the main spore-bearing regions. Do these regions receive any carbohydrates and other elaborated materials from above? Some investigators have surmised a conducting function for the elongated cells in the stipes. Or, do holdfasts and sporophylls have to "find for themselves" while they alwo serve the plant as a whole? These questions, and indeed the whole group of problems involved in the light relationships of kelp, still await their answers. The very instruments and methods to be used in their solution are as yet for the most part undevised.

In its relation to temperature, the final factor in the physical environment, water stands sharp contrast to its relation to light. There it displayed most strongly its power of restriction; here it acts to an equally marked degree as an expansive or distributing agent. That water should serve as a distributor or equalizer of temperature is dud to two well-known groups of phenomena: first, its unique latent-heat capacity and low conductivity, which render it very sluggish in its response to outside temperature changes, and second, the peculiar arrangement of ocean currents ~~in~~ off the Pacific coast. The first group needs no extended discussion, but it may be worth noting momentarily that the equable climates of maritime regions with prevailing sea-winds are governed largely by

the temperature of the water, and that this influence must be transmitted through that most inconstant of all media, the air. The immensely greater equability where water itself is the medium is thus made the more obvious.

The distribution of off-shore currents in the region we are considering is worth studying. The Pacific Current impinges on the North American coast in the longitude of British Columbia. It divides into two streams, one of which flows up the Alaska coast and along the Aleutian Peninsula, while the other flows southward to the end of the Lower Californian peninsula, where it is drawn westward into the equatorial circulation. The effect of this on the temperature of the water is especially striking when one contrasts it with that obtaining on the Atlantic coast, where practically opposite conditions prevail. There, instead of the division of a current of moderate temperature, we have the meeting of two currents, the cold Labrador Stream from the North and the warm Gulf Stream from the south. The results are graphically shown on the accompanying map. On the Pacific side any given set of surface isotherms will be found to extend over a range almost twice as great as that of the same set on the Atlantic side. The isotherms of significance for the present study are distributed from about the Tropic of Cancer to lat. 60°N. on the Pacific coast, whereas on the Atlantic they are all crowded between lat. 30° and lat. 50°. The situation on the Pacific coast is further complicated by an upwelling of cold bottom water close inshore all the way from Vancouver Island to the southern end of Lower California. It is not impossible that the surface isotherms on the map are really inaccurate for close inshore conditions; that on account of this

upwelling they should swerve sharply to the south as they approach the shore. However, data are lacking on this point, and we shall be compelled to make use of what we have, being prepared to modify our statements if inshore temperature measurements should prove our conjecture to be correct.

The map shows so obviously the relation between the occurrence of kelp and the distribution of temperature that a discussion of the subject would appear almost unnecessary. The brown seaweeds in general are cold-water plants; their maximum development, both in number of species and in vigor of growth, is found in circumpolar waters. The kelps, according to all authors, grow as far north and south as the ice permits, being found even in water at -1° and -2° C. Their minimum temperature would thus appear to be close to the freezing-point of walt water. The reported geographic range of at least one of our four species is set at Behring Strait. Their maxima vary with the species; for <u>Macrocystis</u>, apparently the most tolerant of kelps, it seems to be about 20° Centigrade. The summer temperature in the region of Magdalena Bay, the southern limit of kelp on the North American coast, is perhaps somewhat higher than this. The southern limit of kelp (<u>Laminaria</u>) on the Atlantic coast is considerably to the north, at Cape Hatteras, but the summer temperature of the water there is about the same (20°).

Where a plant has both a minimal and a maximal limit to its temperature tolerance under natural conditions, and is limited in its geographical range thereby, it is obvious that its northern boundary will be fixed at the line where it encounters the lowest winter temperature it can survive, and that similarly its southern boundary will be at the line where it

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encounters the highest summer temperature. In other words, the boundaries, so far as they are influenced by temperature, are limited to the zone between the nearest approach to each other of the extremes that the plant can stand. This pair of temperatures, winter minimum and summer maximum, we shall call hereafter the <u>limiting temperatures</u>, and their corresponding isotherms the <u>limiting isotherms</u>.

On account of the specificity of temperature relations of our four kelps, it will perhaps be better to postpone further discussion until we take up the consideration of the particular ecology of each species.

With this we conclude the general consideration of the general physical ecology of the kelps. The matter of biotic environment might be left for the particular discussion, but there are one or two phenomena in this field that are common to all the species, and a word concerning will not be out of place here.

There can be, of course, little competition between the kelps and other species, although it is not impossible that the dominance of the kelps has kept intermediate forms, like <u>Postelsia</u> and <u>Egregia</u>, from invading deeper water; also it is entirely likely that they have kept the Pacific species of <u>Laminaria</u>, which genus dominates the North Atlantic, from attaining a position of similar importance in western waters. Such plants as get started in the marginal zone between typical kelp depths and the range of the rockweeds seem to fare ill in competition with the latter. They cannot stand being stranded by low winter tides as the Fucoids can, and there are probably other

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reasons not yet apparent for their poor development too close inshore.

Little is known concerning competition among themselves of individuals of the same species. A certain amount of crowding seems to stimulate growth; the best-developed plants come from dense, rather than thin stands. However, the same conditions that limit the number of plants in the thin stands may operate also to limit growth in the individual. Harvesting kelp seems to operate on the young plants that have not yet reached the surface in much the same way that removal of excess cover growth in forests operates on young trees. Rigg reports a more rapid growth of sporeling Nereocystis after the removal of the magure plants, and Crandall finds that harvesting Macrocystis stimulates the new growth from the "stolons". The latter case, however, is perhaps more analogous with the growth of redwood "rings"; the fall of the parent plant not only removes the retarding shade, but also directly stimulates the growth of the shoots that are to replace it.

Most ecological discussions must include a section on diseases, parasites and other destructive agencies. Little investigation has been made in this field on the kelps, but on the whole they seem to be very well off. The three most deadly enemies of forests, fire, fungi and insects, have been spared them altogether. True, there are other animals, some of which live on kelp, notably snails and crustacea that feed on its tissues, and certain encrusting colonial animals, like bryozoa, but they are not rated very high as destructive agencies, except in places of slack water. Apparently in normal beds these animals are kept within bounds by the clean-

ing action of the currents. For Nereocystis, Peters considers accidental drying out and mechanical grinding on rocks, etc., more injurious than animal attacks, and probably this holds for other species as well. Rotting kelp has been found in some beds, but whether this is a pathogenic condition due to parasitic bacteria, or whether it is merely a condition of senescence, with secondary saprophytic decay, is not definitely known.

It is not worth while to go into the matter of reproduction to any extent, since that has been considered incidentally in connection with factors discussed above. It may be worth while, however, to call attention to a general consideration on this point. The limiting action of the minima and maxima of all factors operates always most powerfully through the reproductive process. The conditions controlling the existence of a kelp bed are to be found on the ocean bottom, where the life of the plants begin, just as the conditions that control the growth of a forest are to be found on the forest floor. In our discussion thus far we have, to be sure, used surface data for the most part, but that is only because for the most part only surface data are available, and because surface data may be taken as an index of sub-surface conditions, on the assumption either that sub-surface conditions are similar to those at the surface or that such changes as take place proceed more or less uniformly from surface to bottom. But the final study of kelp ecology will have to be made very largely on the floor of the sea, and very largely on conditions as they affect the reproduction and initial stages in growth of the young plants.

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Special Ecology.

With this we may leave the discussion of our kelps as a generalized group, and devote at least a little time to an individual survey of the separate species.

At the first glance, however, we find that there is, on the basis of distribution, a sort of natural pairing of the species into two groups or associations. *Macrocystis* and *Pelagophycus* both reach their maximum development in the south, in the San Pedro - San Diego region, where *Alaria* and *Nereocystis* never occur; while the latter two dominate in northern waters, where *Macrocystis* is found less frequently and *Pelagophycus* not at all. This grouping, however, does not form "associations" in the sense of the term as used by ecologists. Each species as a rule forms "pure stands", and the associated species is found in adjacent patches. There is a bathymetric relationship between the species, which seems to be correlated with the structure and habits of the plants. *Pelagophycus* patches are always on the seaward side of *Macrocystis* beds, and *Nereocystis* always occupies the same position relative to *Alaria*, where the two are found together. In its northern range, *Macrocystis* is sometimes found with *Alaria*, sometimes with *Nereocystis*. In such cases it is always outside *Alaria*, but inside *Nereocystis*. The complete order, from seaward to landward, would be (1) *Pelagophycus* or *Nereocystis*, (2) *Macrocystis*, (3) *Alaria*. Whether such a theoretically possible triple association actually occurs is not stated in the literature; the chances are that if one looked long enough he would find beds exhibiting it. This phenomenon of zoning apparently

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means that the species best able to withstand the buffeting of the waves takes the outside position and the advantages of the larger raw-material supplied that go with it.

The remaining facts within the scope of this paper can best be gotten at by a direct examination of each species taken separately.

Of the species here considered, Alaria is most northerly in its range. It is reported from Behring Straits south to Forrester Island, which is in lat. 54° 50'. Riggs' survey of the kelps of western Alaska does not extend beyond the Aleutian Peninsula, but the earlier reports of an extension to Behring Straits appear to be quite trustworthy, inasmuch as the genus Alaria is circumpolar in its distribution, other species occurring in the Arctic and North Atlantic Oceans, as well as on the Asiatic side of the North Pacific. The southern limit here reported is that given by Frye, and is only a short distance north of the Canada-Alaska boundary. Whether it occurs in Canadian waters cannot be stated from the data at hand. If it does, however, it cannot extend much further south, for the southernmost stands here noted are not heavy ones, and Alaria is associated in them with Nereocystis. It is not reported from the Puget Sound region. Its range in latitude places it between limiting isotherms for approximately -2° and 13°. It is a little difficult to determine from the data available exactly where Alaria reaches its maximum development, but it would seem to be in the region of Kodiak Island and the Kenai Peninsula. Here it occurs extensively as pure stands, whereas farther south, along the "panhandle" coast, it is generally associated with Nereocystis.

Alaria does not usually occur at as great depths as the other kelps prefer, being found in water of from less than one to five

or six fathoms. Plants as much as sixty feet long have been measured, but there is generally a considerable part of the plant floating on the surface. There is nothing to indicate to indicate that this preference for shallower water is primarily involved with a difference in light requirement; more probably it is due to other factors, especially to its broad, flat form, obviously less well adapted to existence in rough water such as the other kelps prefer. All observers agree that Alaria will grow in quieter water than the other species will tolerate.

Its perennial and indeterminate habit of growth have already been referred to. If other factors were favorable, this growth habit might make it desirable from the commercial point of view. However, its yield per unit area is not so high as that of the other kelps, and moreover it is much farther from manufacturing and market centers than they. It will probably be the last of the great kelps to be exploited commercially.

Nereocystis is associated with Alaria through a large part of the range of the latter, and reaches a lower latitude, being reported as far south as Point Conception, California. It has been reported from the Behring Sea, but there is room for doubt as to whether it occurs there except as floating massed drifted up from the south. A further reason for doubting its occurrence here is that, unlike Alaria, the genus is not circumpolar, but is limited to the range here outlined. The most northerly occurrence reported by Rigg is in the neighborhood of the Kenai Peninsula. Its limiting isotherms appear to be 0° (or possibly -1°) and about 18°.

Neoro

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Nereocystis has a very considerable range in depth. Crandall found it in water as shallow as one and one-half fathoms, and as deep at eighteen. In general it grew in deeper water toward the southern limit of its range. The depth of one and one-half fathoms is exceptional, the usual figure for the Puget Sound region, where this species reaches its maximum development, being six or eight fathoms.

Nereocystis is the Viking among the kelps. It delights in rough water. In its association with _Alaria_ and _Macrocystis_ it always takes the seaward side of the bed. In Puget Sound and in the channels among the islands it grows only in places swept by strong tidal currents. It grows right up to the very edges of the steep rocks in these waters, so close as sometimes to be injured by being dashed against them.

The plant, as noted before, is an annual. The beds are swept empty every winter, only a few individuals surviving until the following season. Its life history is still largely a matter of conjecture; not even its time for sporulation is accurately known. Cameron gives July 15 as the earliest date at which it may be harvested in the Puget Sound region without harm to the next year's crop; and some time in August for the harvesting of the Alaskan beds.

Economically, _Nereocystis_ offers the advantages of growing, throughout a good part of its range, near good harbors and markets. The concentration of most of its mass at the surface, in the thickened end of the stipe, the pneumatocyst, and the "head" of laminae, would make it a very suitable form for harvesting.

However, its annual habit, limiting it to one crop a year instead of the three or four possible with *Macrocystis*, will probably postpone its exploitation until after the latter species shall have come fully into use.

South of Point Conception *Pelagophycus* succeeds *Nereocystis* as the deep-water, rough-sea kelp. It is seldom found alone, but occurs as patches on the seaward borders of *Macrocystis* beds, and ranges with that species to its southern limit at Magdalena Bay. It thus has the shortest range, in latitude, of any of the kelps. The limiting isotherms are approximately 14° and 25°. That a 11-degree range between summer maximum and winter minimum can be found in this relatively short distance is explained by the northward crowding of the summer isotherms along the Mexican coast. The oceanic causes underlying this crowding are too complex to be discussed here.

Pelagophycus does not occur in sufficient abundance to be of commercial importance, but is taken in along with the *Macrocystis* on whose flanks it is found. It would be rather a pity if this kind of harvesting should destroy the species, for it is the biggest and handsomest of the kelps; but until a revival of the kelp industry on a large scale has occurred there is no reason to waste any worry over this.

The most interesting of the kelps, from both the ecological and commercial viewpoints, is *Macrocystis*. Its range in the region we are concerned with extends from Magdalena Bay on the south to about the latitude of Sitka on the north. Its greatest development occurs between Point Conception and San Diego, and among the Channel Islands. The limiting isotherms would thus appear to be 5° and 25°. Too much significance should not be

attached even to these limits, for Macrocystis is found in many other waters, so widely distributed as apparently to justify its title as the most widely disseminated plant in the world. There is little doubt at least that it is the most widely distributed seaweed species. Its appearance in northern waters represents, apparently, a migration far from its original home, for it is essentiall an antarctic plant. Hooker has described it from lands all about the South Pole: Fuegia, Australia, Cape of Good Hope, Kerguélen Island, Heard Island, Tristan d'Acunha, St. Paul Island, and the Crozets. Its southern limit is fixed by the ice. It has no extension northward on the African coasts, and but little on the Atlantic coast of South America; but it is found all along the western shores of that continent to the equator, being favored, probably, by an upwelling of cold water from the Andean Trough similar to that which rises along the Pacific coast of North America, and also by the fact that the isotherm of maximum oceanic temperature runs somewhat north of the equator. Carried across this zone of torrid water, probably as driftweed in the winter, it has continued its northern march--or perhaps more properly, voyage--along the North American coast. Crossing the northern end of the Pacific Ocean, it has established itself on the coast of Kamchatka and in the Sea of Okhotsk. It is reported from the coast of China, and also, through with an unknown degree of certainty, from Tahaiti. It is not known from Japan, nor has it yet invaded the Arctic or North Atlantic. The reported occurrences in the Behring Sea are probably only as floating masses, and its presence in one or two of the other less carefully examined areas may also be only as drift. The ability of this species to migrate as it apparently has would seem

to imply a high degree of viability, either of the drifting plants or at least of their spores. Possibly its perenial habit, with the apical location of a spore-producing region, might account for its excellent adaptation for long migrations. But this again is conjecture, and awaits investigation.

Wide though its geographical distribution is, Macrocystis enjoys no advantage over other kelps in the matter of bathymetric distribution. Though it has been reported as occurring in depths as great as sixty fathoms, and growing to lengths of six or seven hundred feet, these figures must be considered more than doubtful in the light of actual soundings and measurements made by Setchell, Rigg, Frye, Crandall and others. Six to twelve fathoms in Alaska, and about fourteen in California, with a maximum of about twenty fathoms, seem to fit the actual situation better. The greatest length among the measured plants was about forty-five meters.

As experience before and during the war demonstrated, Macrocystis is the most available of the kelps for commercial purposes. Its abundant and continuous growth, its renewal from the "suckers", its occurrence in waters relatively free from tortuous channels and uncharted rocks and with a long stormless season, and finally its proximity to facilities for handling and marketing combine to set it at the top of the list of economic possibilities among sea plants. When a revival of the kelp industry takes place we may confidently look for the new factories where we saw the old, behind the San Pedro breakwater and on the shores of San Diego Bay.

1918 Kelp Harvest.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.
Hercules	26700	19065	31635	26795	24180	21000	21600	30525	19925	19075
Swift	5121	1681	2455	3505	1968	779	3400	5180	5935	4375
Diamond	3033	1621	3091	4637	5118	5171	3957	4008	852	1960
Pacific Products					5333	789	2433			
Sea Products	2107	510	1525	1730	2140	1750	2477	1860	1150	1800
Lorned	2950	1641	1435	3163	2065	1728	3222	4249	4456	4500
Hand Pickers	1846	1496	766	2038	3164	3547	3302	3646	2618	2070
Occidental	896						666			
Federal Kelp	465	640	985	1141	1720	218	1026	1039	469	
Incidental			24		150	40			20	
	43118	26654	41916	43009	45838	35022	42083	50507	35425	33780

La Jolla.

La Jolla, Cal.

Jan. 22nd 1919.

Dr. Edward Krehbiel,

Director Speakers Bureau,

Food Administration,

San Francisco, Cal.

My dear Dr. Krehbiel:

Your letter of the 9th at hand. I am sorry that I have been responsible for h lding back any work that you had in hand. I have been hard at work straightening out the files so as to make a connected story of the work as I unde5stood you wanted that kind of a digest. I am now sending you an article prepared for the "Fishermen" that I think will more nearly cover what you want with additions of orders issued, files now completed, and personal data.

Trusting that this will cover up my delinquency, I am

Very trulybyours,

W C Crandall

Fed. Fish Adm. for So. Cal.

25-479 11/4/18

November 4, 1918

DATA DESIRED FOR THE HISTORY OF THE CALIFORNIA FOOD ADMINISTRATION

NAME ______________________

Wesley Clarence Crandall

ADDRESS ______________________

La Jolla, Cal.

BUSINESS OR PROFESSION ______________________

POSITIONS WITH THE ~~FOOD ADMINISTRATION, WITH DATES~~ Institution for Biological Research. of the Univ. of Cal.

Federal Fish Commissioner for Southern California

February 1, 1918 - Dec. 31 1918

January 1 1919 - May 31st 1919.

(For each of the following use separate sheets)

PERSONAL NARRATIVE (This narrative will presumably be roughly chronological and should be accurate. It should include personal achievements, experiments, experiences, dramatic episodes, human interest stories, humorous incidents, problems, speeches and the like in your service of the Food Administration; also your administrative organization and its development, including the names and functions of your staff. (See below). Also your relations to the public, the press, business, etc; and the attitude of the public toward the Food Administration. Copies of interesting correspondence, or other materials are desirable.)

PERSONNEL (To secure as complete a list as possible of the personnel of the Food Administration, give a list of your staff, noting address, business, position with the Food Administration including dates, and whether the service was volunteer or paid.)

RECORDS (A statement about your office records is desirable, noting their general character, quantity, arrangement, etc. They should not be destroyed but be held for instructions as to disposition when the time comes.)

(If possible send the reports in typewriting together with two carbon copies)

By an Act of Congress of August 10th,1917, it was provided,among other things, as follows:

" That, by reason of the existence of a state of war, it is essential to the national security and defense, for the successful prosecution of the war, and for the support and maintenance of the Army and Navy, to assure an adequate supply and equitable distribution, and to facilitate the movement of foods,*********and equipment required for the actual production of foods******* *; to prevent, locally or generally, ~~se~~ scarcity, monopolization, hoarding, injurious speculation, manipulations, and private controls affecting such supply, distribution, and movement; and to establish and maintain governmental control of such necessaries during the war.*********The President is authorized to make such regulations and to issue such orders as are essential effectively to carry out the provisions of this Act.******The President is authorized to issue such licenses and to prescribe regulations for the issuance of licences and requirements for systems of accounts and auditing of accounts to be kept by licensees, submission of reports by them********and the entry and inspection by the President's duly authorized agents of the places of business of the licensees".

This Act of Congress was approved by the President August 10th,1917, and thereupon the United States Food Administration was given the power to license, among others, fishermen and canners of fish;and to set aside State Laws governing oceanic fishing wherever such laws tended to lessen the present supply of either fresh fish or fish for canning.

In compliance with the duties and powers thus ascribed to it, the California Food Administration undertook the settlement of the price to be paid the fishermen by the canners, for sardines. The Honorable Stoddard Jess of Los Angeles was given the task of investigating the situation and rendering a decision. His decision, dated January 1,1918, was that the ~~fishermen should~~ maximum price that the fishermen should be allowed for sardines,small or large,should be fifteen dollars per ton.

and furthermore that the fishermen should not be given free rent, water light, or gas, or bonus of any other kind. Although dissatisfied with the price for "quarter-oil" sardines, the fishermen who had been idle pending the settlement, at once returned to work.

On february 19th, 1918, the Unites States Food Administration appointed the writer as Federal Fish Administrator for Southern California with jurisdiction over the territory between Santa Barbara and San Diego; and with the duties of seeing that the regulations of the United States Food Administration were carried out; of designating what laws had best be set aside for the period of the war; of determining the price to be paid for fish used in canning; of supervising the acts of all fishermen in the territory; and of inspecting the business methods of all dealers in fish. In the performance of these duties, the Fish Administrator was assisted by all of the Inspectors of the National Canner's Association, by the State Fish and Game Commission, the United States Attorney, the State Market Director, ~~offi-~~ the Officers of the U.S. Harbor Patrol and ~~the~~ Submarine Base, the U.S. Department of Justice, and various Intelligence Bureaus. From the outset it was apparent that the fishermen were divided into several distinct types, and, similarly, that they had special methods of fishing and that, too, in limited seasons. For example, the Sicilians form the larger number of crews for sardine-fishing, and ~~they~~ excel in the use of the lampara net; the Genoese, for the most part, form the crews for barracuda, sea-bass, and halibut-fishing, and excel in the use and care of drift nets and trammel-nets; the Japanese confine themselves mostly to fishing for albicore, tuna, skip-jack, and yellowtail, and more proficient than others in the use of rod and line , and live bait as chum. This bait, by the way, is caught in small lampara nets and is kept alive in the bait tanks by continuously renewed salt-water; The Austrian handle the large purse-seines to best advantage, and catch bluefin tuna, yellowfin tuna, skipjack, and mackerel. Their exceptionally large catches during a part of the 1918 season was the means of saving the canners from disaster. The Norwegians are especially proficient in the use of set-lines for rock-cod, sheepshead,

and other fish inhabiting rocky bottoms; and the Americans prove the exception to the rule in that, while engaged in small numbers in all lines of fishing, they seem equally proficient in all.

The catches are delivered either to fresh fish markets or to canneries. During the past year, the Santa Barbara markets were supplied by fish from Santa Barbara Channel, the catches consisting mainly of halibut and rockcod with some yellowtail, barracuda and seabass. The San Pedro markets received fish from the banks off Santa Cruz Islands, Cortez Banks, and waters along the shore from Pt. Dume to Pt. San Juan, the caeches consisting of rockcod, barracuda, seabass, mackerel, whitefish, and a small quantity of tuna; while the San Diego Markets were supplied by local barracuda, seabass and mackerel, and a larger quantity of halibut, barracuda and seabass from Mexican waters.

The canneries received sardines, albicore, bluefin tuna, yellowfin tuna, bonita, skipjack, yellowtail, and mackerel. Because of the lack of albicore this season, yellowtail was canned in large quantities for the first time, and so successful was it, that henceforth it must be considered one of our important canned products. As to the number of canneries in operation during the past season, there were nine in san Pedro and EastSan Pedro, three at Wilmington, six at Long Beach, and ten at San Diego. A fleet of 450 boats supplied the canneries of San Pedro and vicinity, and a fleet of 200, the canneries of San Diego.

One of the first official acts of the Fish Administrator was to readjust a portion of the Stoddard Jess decision. After conferences with fishermen and canners, the price of $25.00 was set for sardines measuring not more than seven ~~and-one-half~~ inches inches in length, loaded not more than eight inches deep on the boat, and delivered in prime condition. The price of $7.50 per ton was set for sardines which had to be made into fertilizer on account of being rejected by the inspectors. These prices were announced to be in effect for the duration of the spring season and until such time thereafter as prevalent conditions necessitated a new agreement.

On May 3rd, several of the California State laws were temporarily set aside in order to stimulate the fishing industry. The changes made were, briefly, these; that certain fish which it had been unlawful to sell, even though the fish were caught, could now be sold; that drag-nets might be used outside the three mile limit and might be carried but not used while crossing district 19, whereas before it had been unlawful even to have dragnets in ones possession in that territory; that baitnets might be used in the waters adjacent to Santa Catalina Island: and "baby"halibut, i.e. under 4# weight, and "baby" barracuda, i.e. under 18" length, might be sold if they had been caught incidentally.

To set a reasonable price for fish brought from Mexican waters during the summer season was the next problem. The unparalled increase in the cost of gear, approximately 250 per cent, and the raise of import duties and clearances made by the Mexican Government added much to the difficulties of this ever-difficult problem. Moreover, the hauls of the early spring had been small and anything but promising, and it was only after the most careful investigation of records of both fishermen and ~~canners~~- dealers, and the thorough study of all data that could be obtained, orally or written, that a decision of price was made. The fishermen began fishing, however, and after one or two slight adjustments, kept their part of the agreement ~~throu~~ throughout the entire season, and the freshfish market was more stable than it had ever been before. On July 15th all matters pertaining to price-fixing for fresh fish were turned over to the State Market Director with the the understanding that the prices which he set should have the approval of the Food Administration. On November first, accordingly, a new schedule of prices for the winter season was issued.

In the meantime, the Fish Administrator had been called upon to draw up the regulations of the tuna industry and to ~~set~~ determine the price for tuna for the season ending January 1919. All the data available was gathered during the spring, and on June 12th, the regulations suggested were announced from the office of the California Food Administrator.

The price set was $100.00 per ton, and bonuses of rent, taxes, interest on money, or any other sort were forbidden. The Japanese refused to fish for that price and consequently, although the white fishermen for the most part went out as usual, the first run of tuna was practically lost. Conferences between the parties concerned were frequent during the month of June, but no agreement was reached until July 15th when, largely through the efforts of Lieutenant Wilbur of the U.S. Submarine Base at San Pedro, the settlement was made that the tuna fishermen would go to work if they were paid a uniform bonus of $10.00 per ton for albicore only, the fish to be cleaned and delivered in prime condition. No further trouble worht mentioning, so far as the fishermen were concerned, occurred during the remainder of the tuna season, but because os some oceanic condition, the run of albicore was extremely short and the resultant tonnage ~~of canned product~~ for the season was only 9,000 whereas in 1917 it had been 15,000. The fact that 1500 tons of yellowtail were caught relieved the situation, but from the standpoint of the fishermen who had at great cost procured larger boats and larger nets in expectation of a big catch, the season was a failure. The total pack for the year on the basis of half-pound cans and 48 cans to the case, was only about 400,000 cases. In 1917 it was approximately 500,000 cases.

Fish which in former seasons had been accustomed to be found between Pt. Conception and Todos Santos Islands were found this season with their northern limit of range near Monterey and their southern limit near San Clemente Island. In other words, while San Pedro had all the tuna there were, San Diego had ~~almost~~ none, and had to can yellowtail. Similarly, fish which ordinarily are found along the southern coast of Mexico were found this year much farther north. Whether this was due to weather conditions is not known, but it is a fact that the temperature of the water was 5degrees higher than normal, that there was a lack of the usual northwesterly winds, that there were more than the usual number of sunshiny days, and that ~~ther~~ there was a very evident northerly movement of waters off shore.

Late in June some of the fresh fish dealers began to offer more for tuna, albicore, and some other fish under license to canners, than the canners were permitted by the Food Administration to pay. Evidence of such overpayment was found when, under authority of the Act of Congress cited above, certain places of business and certain boats were searched. Trial was held under the Honorable Sayre Macneil of the law enforcement division of the Food Administration, and the dealers and boatmen concerned were found guilty. Two fresh fish markets were closed October 28th for a period of thirty days. They were permitted to reopen November 21 because in the meantime the armistice had been signed.

In August Col. Burwell, Commander of the Norht Island Aero School appealed to the Fish Administrator for the closing of the marine league along the shore from Pt. Loma to the Mexican border, which area he said was necessary for practice bombing and firing from aeroplanes of the advanced school of aviation. By agreement with the fishermen and kelp companies, the area was ~~was~~ closed to boats from 8 A.M. to 6 P.M. for an indefinite period of time. On September 28th another law was temporarily set aside and permission was given for bait to be taken from the waters of Newport Bay for the use of the fishermen of that region.

In the early part of October the Administrator appointed an Advisory ~~Boar~~ Board to help settle questions involving Long Beach and San Pedro interests This board was composed of three non-partisan members, Lieut. Wilbur of the Submarine Base as chairman, Mr. Loucks of San Pedro, and Mr. Dorsett of ~~Lon~~ Long Beach; three cannerymen, two representing associations and one independent, namely Mr. Houseils, Mr. Van Camp, and Mr. Hurst; and three fishermen, Mr. Dorsey, Mr. Uijedi, and Mr. Esposito. This advisory board met October 12th with the Fish Administrator and Mr. Munn, Head of the Canneries Division of the Food Administration, Washington, D.C., and agreed upon the price to be paid for sardines until May 31, 1919, which price is $30.00 per ton for "quarteroils", ~~71/2~~ senen and one-half inches long, and not more than 8" deep on the boat, and $10.00 per ton for fish for fertilizer. The effect

of the price at Monterey upon the industry in the South was carefully considered before this price was set.

On October 20th permission was given for red and pink abalones to be taken, by divers, from the waters of District 19 provided that none should be taken which were less than 15 feet below low-water mark.

The waters along Catalina Island from Long Point to the northern end of the island and thence around to the southeast end of Seal Rock were opened to commercial fishermen on November 4th, for the winter season, i.e until May1,1919. By this arrangement the difficulties of winter fishing are somewhat lessened, and yet the waters directly adjacent to Avalon are retained for pleasure-fishing.

The Food Administration realizes that whatever degree of success it attained was possible only because of the earnest and hearty cooperation of the men engaged in all branches of the fishing industry, and to them, one and all, fishermen, canners, dealers, and assistants, the Food Administration extends its thanks.